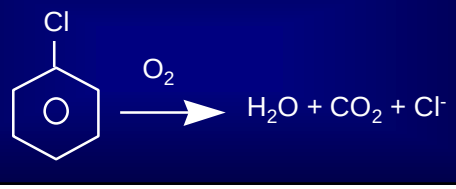
Bioremediation of Chlorobenzene-Contaminated Groundwater

A Collaborative Effort between US AFRL/MLQ and DOW Chemical for Effective Above-Ground Treatment of Chlorobenzenes

THE CHALLENGE

Chlorobenzene (CB), a solvent previously used to clean weapon systems and in chemical manufacturing operations, is persistent in the subsurface. The current challenge for bioremediation of manmade solvents is the discovery or development of microorganisms able to biotransform such chemicals. Evidence indicates that naturally occurring microbial transformation processes are evolving. AFRL/MLQ in-house researchers discovered indigenous bacteria able to degrade CB, a compound once considered to be non-biodegradable. Discovery of the bacteria and bench-scale investigations of the degradation mechanisms led to three successful field demonstrations.

Aerobic Microbial Transformation

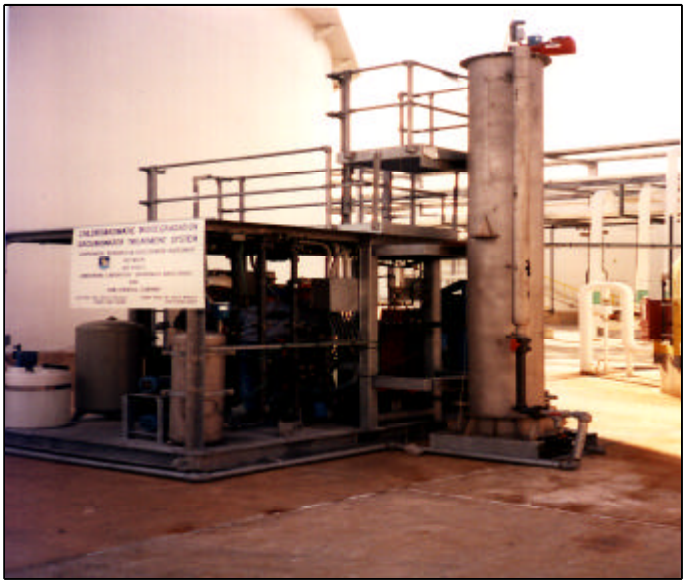


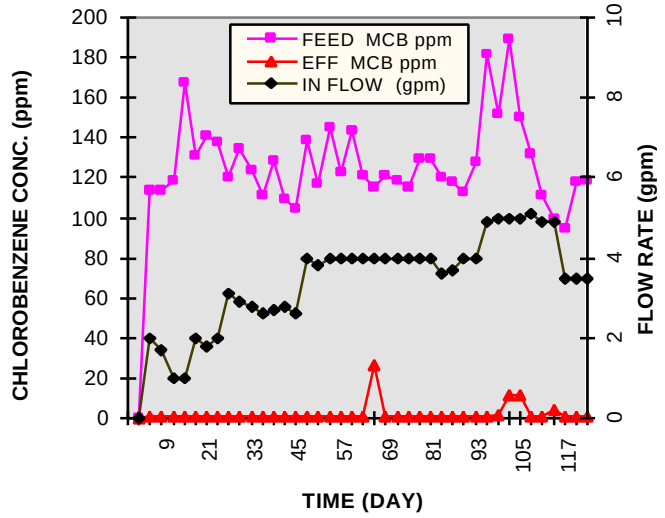
IMPLEMENTATION

Pseudomonas sp. strain JS150 has the unique ability to biodegrade a broad spectrum of chlorinated aromatic solvents, either alone or in combination. Determination of biochemical pathways and reaction mechanisms led to two pilot-scale packed-bed bioreactor studies involving inoculation with strain JS150.

Results indicated that indigenous strains from long-term chlorobenzene-contaminated sites competitively replaced JS150. CB-degraders can be readily isolated from wells with a long history of contamination, whereas, in uncontaminated wells, CB-degraders are not present. Although the indigenous populations degraded CB-contaminated groundwater as effectively as JS150, inoculation eliminates the initial acclimation period.

Pilot-scale success led to a Cooperative Research and Development Agreement (CRDA) between AFRL/MLQ and Dow Chemical to conduct a large-scale demonstration at a CB-contaminated site using a granular activated carbon fluid-bed reactor (GAC-FBR). GAC-FBRs are widely used to treat readily degradable organic compounds, but application for treatment of synthetic compounds has thus far been limited. The reactor was inoculated with activated sludge and groundwater containing CB-degrading organisms from the site. Over 99.99% of the CB was removed even during loading rates in excess of the design loading rate. A cost analysis showed the costs for groundwater treatment using the GAC-FBR were generally lower than to the more conventional methods. GAC-FBR costs ranged from $2 to $13 per 1000 gallons depending on the influent concentration and flow rate.





FUTURE EFFORT

The discovery of indigenous CB-degraders at contaminated sites provides evidence that natural attenuation processes are occurring. Current studies are determining the mechanism of acclimation of indigenous microorganisms during long-term exposure to CB contamination. The goal is to predict aerobic and anaerobic biodegradation processes that occur during natural attenuation.

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